Moulded body reinforced with carbon fibres

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Abstract of **DE19749462**

Silicon is infiltrated into the moulded body to increase its mechanical strength. Production of a moulded body reinforced with carbon fibres comprises infiltrating a porous carbon fibres containing preform of the moulded body made of polymer resin based on phenol and hardening, pyrolysing the green body obtained to convert the polymer resin into carbon into which silicon, preferably in liquid form, is infiltrated at 1400 deg C. Before pyrolysis, the preform infiltrated with polymer resin is heated to a heat treatment temperature which is 20-70 deg C above the temperature at which the polymer resin hardens. The heat treatment temperature is maintained for at least one hour and then the green body is cooled to room temperature at a rate \- 30 deg C/hour. During pyrolysis, the green body is subjected to mechanical pressure which increases with increasing green body thickness. After the pyrolysis has ceased, the green body is cooled to room temperature at a rate of 30-300 deg C/hour.

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Moulded body reinforced with carbon of fibres

Description OF **DE19749462**

The available invention concerns a procedure for the production one with carbon fibers of strengthened, keramisierten molded article, with which into carbon fibers a containing, porous gathering mold of the molded article polymer resin, in particular a polymer resin on phenol basis, is infiltrated and hardened, the in such a way received green body of a pyrolysis for the transformation of the polymer resin in carbon is subjected and in these thereafter silicon, in liquid phase, at a temperature of at least 1400 DEG C infiltrated, with carbon to siliziumkarbid is preferably reacted.

Further the invention concerns the use according to invention of a molded article manufactured in the procedure.

A procedure that managing indicated kind is well-known from GB-HP of 1,457,757. After this block letters such molded articles are manufactured, which exhibit a matrix, which consists of siliziumkarbid and elementary silicon. Because the matrix of the molded article contains free silicon still to substantial extent, is not favourable the use of this molded article at temperatures, which lie in the range of the melting point of silicon. Straight such temperatures, which lie within the range of 1400 DEG C, can develop for brakes with the employment of such molded articles as friction units, in particular. By softening the silicon at these high temperatures a sufficient braking action is no longer ensured. In addition the mechanical characteristics of such molded articles can be strongly impaired. Further the problem is present that itself if liquid silicon on solidification temperature is cooled down, the silicon expands and thus internal tensions in the molded article develop, which questions and/or at least strongly affects its usefulness.

On the basis of that managing indicated state of the art and the shown problem the available invention the task is the basis to train a procedure further of the kind initially specified in such a manner that the molded article exhibits a content of free silicon after the infiltration of the silicon, which amounts to smaller 2% related to the mass of the molded article and whose porosity 5% related to the total volume of the molded article is smaller.

The managing task is solved according to invention by the fact that before pyrolysis the gathering mold infiltrated with polymer resin is heated up on a thermal treatment temperature, which is appropriate for 20 DEG C to 70 DEG C over the temperature, at which the polymer resin hardens that the thermal treatment temperature is cooled down for one duration by at least 1 hour of maintained and afterwards the green body on ambient temperature with a cooling rate of at least 30 DEG C/h that during the pyrolysis of the green bodies, of a mechanical pressure load rising with increasing thickness of the green body, insb. Surface pressure is subjected, and that after conclusion of the pyrolysis of the green bodies with cooling rates within the range of 30 DEG C/h to 300 DEG C/h on ambient temperature one cools down.

By this pretreatment of the gathering mold before the infiltration of the silicon, inbesondere by the defined thermal treatment and the pressure load and/or surface pressure become during pyrolysis, and by the defined cooling of the green body after pyrolysis on ambient temperature Poroesitaeten in the form of translaminaren tears or channels produces. Thus it is guaranteed that after after the infiltration of silicon into this void structure and the Silizierung the portion of free silicon, related to the mass of the molded article amounts to, smaller 2% and related to the total volume does not exceed porosity 5%. This small portion of free silicon guarantees that the molded article high temperature loads stood holds, into the range of the fusing temperature of silicon and in addition is enough. Further by the defined thermal treatment tensions in the gathering mold of the molded article are diminished and thus the distortion and Delaminationsgefahr during following, pyrolysis which can be made are reduced. In addition the temperature treatment leads during the Silizierung at a temperature of < 1800 DEG C for a length of time of at least 3 hours or at a temperature of > 1800 DEG C to approximately 2100 DEG C for a length of time of less than 3 hours to low porosity and low, free silicon contents.

The procedure according to invention brings further the advantage with itself that for the production of the molded article long and/or endlosfasern from carbon is applicable. Such long and/or endlosfasern leads again to a molded article, which possesses a high mechanical firmness. For example the bending strength can even lie within the range of 50 MPa or over it. Also the molded article manufactured in the procedure

by a small delay and a high figuration regret in all process steps are characterised. This means that the arising molded article can be already dimensioned during the individual manufacturing steps with the end form approximated masses. This applies also with the green body production and pyrolysis, since the decrease is small. Thus also no addition from powders is necessary to the reduction of the decrease and/or porosity. It is of advantage with this procedure that the green body thereby consists only of two raw materials; on the one hand the fiber stand and on the other hand a matrix made of liquid polymer, i.e. powder additions are avoided into the matrix and/or not necessarily, what brings technically advantages going by with itself that during the manufacturing and infiltration of the fiber stands a fast infiltration is possible and is producible large construction units, since due to the missing powder a Ausschwemmen of such powders is not given. Molded articles according to invention can be manufactured further with fiber contents, be amounted to up to 70 volume % related to the total volume of the molded article. Such high contents of carbon fibers lead to a high firmness of the final body with a small decrease during the individual manufacturing steps. The procedure permits in addition a locally different structure of material by attitude of fiber orientation and/or the fiber content, whereby favorable, material-conforming force applications are possible into from the molded article manufactured the construction unit, depending upon requirements. In order to ensure an even penetration, for example a fabric gathering mold from carbon fibers with polymer resin, prefers the polymer resin over a section of fabric edge (i.e. an edge, which lies perpendicularly and/or transverse to the gewebelagen) parallel to the gewebelagen and over the entire thickness of the gathering mold into the gathering mold injected. Here the Vorkoerper can be brought into an appropriate admission, so that the section of fabric edges remain freely, over which the polymer resin defined is then injected. The infiltration of the polymer resin should take place here with a difference of pressure from 0,1 bar to 10 bar. In addition the gathering mold before injecting the resin should be degassed, in order to remove volatile components. As polymer resin in particular a phenol of the type Resol is suitable, whereby however such, solved with water or alcohol (e.g. ethanol), which is solved in water, is to be preferred. Such a phenolic resin is not low-priced and required, in particular due to the solubility in water, environmentaltechnical measures, which would be necessary with other volatile solvents otherwise.

In accordance with a further measure the thermal treatment of the gathering mold infiltrated with resin is accomplished in air atmosphere with ambient pressure. The thermal treatment, as it is indicated according to invention, leads to the formation of defined tear structures, which affect segmenting the matrix, i.e. the training of the translaminaren matrix channels with pyrolysis. This takes place for example via the fact that a later (after pyrolysis available) microcrack sample ansatzweise is already present before pyrolysis, whereby the danger is reduced by wide defects, like for example Delamination, clearly. Thus the structure of a microstructure with gap widths between 5 is favoured over and 25 mu m for the following Silizierung. With these gap widths a content of free silicon can be achieved after the Silizierung smaller 2%. A further advantage of this procedure is that that only a unique pyrolysis and only a unique Silizierung are necessary, which bring the advantage with itself that a Nachinfiltration of the matrix is void and that thereby a fast trial process is ensured.

The dismantling of tensions, which develop in the gathering mold of the molded article, can be accomplished for the gathering mold carefully by the fact that for the reaching of the thermal treatment temperature the thermal treatment is accomplished in stages with different heating rates. These heating rates of ambient temperature up to thermal treatment temperature lie within the range of 30 DEG C/h to 300 DEG C/h.

It was stated that by a mechanical pressure load, insb. Surface pressure, as the green body with punched and/or genuteten graphite or steel plates is weighted during pyrolysis, is affected in such a way the cracking in the green country that gap widths between 5 mu m and 25 mu m are reached, in particular also under the criterion that the emergence is prevented by Delaminationen. With this microcrack structure with gap widths between 5 mu m and 25 mu m, which will receive after pyrolysis, a content of free silicon is guaranteed of smaller 2% after the infiltration of silicon. The surface pressure should be accomplished preferentially with genuteten plates, whereby the portion of the contact areas lies between the slots, which rest upon the gathering mold of the molded article, between 30% and 60% of the total disk surface. Such plates should preferably rest from two facing sides against the green body. It was shown that with a structure of laminate with two-dimensional fabric layers only one pressure load is perpendicularly for the fabric levels necessary. Further it was stated that the necessary surface pressure with increasing construction unit thickness rises. The respective, minimum, necessary surface pressure in form of the pressure P (the pressure on the Vorkoerper during pyrolysis), which can be used, can by P = 100 + tx65 [N/m<2 >] be calculated, whereby t indicates the wall thickness of the gathering mold in [mm], toward the application of pressure.

By an even distribution of the mechanical pressure load on the green body it is guaranteed that during the pyrolysis of the green bodies it is stabilized and a delay is prevented.

In order to increase the economy of the procedure, the pyrolysis of several green bodies can be accomplished in stacked arrangement. Here in the changing structure genutete pressure plates and green body are laminated in such a way that a pile forms.

Preferably pyrolysis under inert gas or with a pressure should be accomplished </= 1 mbar; thereby it is reached that an oxidation of the green body is avoided and a high carbon yield of the polymer resin is obtained. If inert gas is used, nitrogen should be preferably used, whose purity amounts to at least 99.96%. In addition rinsing gas rates of the inert gas should be stopped when using inert gas of up to 30 l/min. per cubic meter of furnace volume, in order to ensure an easy and safe evacuation the set free gases during pyrolysis.

Regarding those managing indicated advantages procedure in accordance with pyrolysis with heating and cooling rates is accomplished within the range of 30 DEG C/h to 300 DEG C/h, preferentially with heating and cooling rates by 100 DEG C/h.

It worked satisfactorily to accomplish pyrolysis in three heating stages whereby the first heating stage up to the thermal treatment temperature with a heating rate within the range of 50 DEG C/h to 300 DEG C/h, which second heating stage with a heating rate within the range of 5 DEG C/h to 300 DEG C/h, until at least 70% of the transformation of the polymer resin took place in carbon, and which third heating stage with a heating rate within the range of 50 DEG C/h to 300 DEG C/h up to the pyrolysis final temperature are accomplished. Particularly good results are obtained if the first heating stage with a heating rate is accomplished by approximately 100 DEG C/h, while the second heating stage with a heating rate by approximately 10 DEG C/h and the third heating stage with a heating rate of approximately 100 DEG C/h should be accomplished.

For an even silicon infiltration an essentially constant temperature should be maintained during entire infiltrating. The length of time, while that is to be maintained the temperature necessary for the infiltration, depends strongly on the selected temperature, whereby with higher temperature the length of time, which is necessary for the infiltration, decreases. If a temperature is stopped during the infiltration of smaller 1800 DEG C, this temperature should be maintained at least 3 hours. However for the silicon infiltration if a temperature is selected within the range of 1800 DEG C to approximately 2100 DEG C, the length of time, for which this temperature will maintain, should amount to less than three hours.

If the gathering mold from a fabric laminate from carbon fibers is developed, the silicon is supplied transverse to the laminated structure of the structure of laminate. In order the reaction of the infiltrated silicon with free carbon, which is present after pyrolysis, to arrange reproducible, should be used a silicon, impurities of less than 9 ppm contains.

In order to infiltrate several pyrolysierte Vorkoerper at the same time with liquid silicon, the green bodies inserted into graphite tubs arranged one above the other in such a manner that the soil of a graphite tub on the edge of the underlying graphite tub rests upon in each case. In addition each graphite tub is provided with a parting agent. Preferably it concerns a suspension, which contains an aqueous solution from boron nitride powder and an adhesion mediator. This parting agent from boron nitride powder and adhesion mediator is applied on the surfaces of the tub and remains, after removing the infiltrated molded article from the tub, on the tub surfaces. Such a parting agent affects in addition not the molded article in its structure or in other way.

Since with the procedure according to invention the decrease, which in addition it is very small, can be defined and reproducibly adjusted is it possible to dimension between the pyrolysis of the green body and its following Silizierung this with consideration from simple changes of measure to whereby this change of measure amounts to about 2% related to the dimensions of the pyrolysierten green body, in order the desired final dimensions to obtain. Finishing keramisierten molded article is, if at all, only to small extent necessarily, since due to the measure addition during processing of the pyrolysierten green body the change of measure, which arises during the Silizierung, amounts to smaller 2%. By the accuracy to size, which is attainable with the procedure according to invention, are, if at all, only small rework steps necessarily, in order to keep and/or achieve the desired dimensions. Thereby it is ensured that protective layers, which are formed, remained during the Silizierung and can as function surfaces be used. During a

too strong rework otherwise these protective layers would be removed to a large extent or completely. Such protective layers, which will receive, can be used in particular as corrosion and oxidation protective layers, which when manufacturing brake letters in accordance with the procedure according to invention is particularly favourable.

Remark example

In the following the manufacturing of a plattenfoermigen molded article with final dimensions is described by 286 mmx286 mmx14 mm.

As raw material symmetrical carbon textile fabrics used with the following specifications:

- HT carbon fibers with 12,000 filaments (HT means high-strength fibers)
- fabrics with canvas connection from HT fibers
- weight per unit area 460 g/m<2 >
- phenolic resin of the type Resol with a viscosity of approx.. 100 mPa.s, a carbon yield of approximately 60% and a solvent portion of approx.. 15% (water).

The production of the gathering mold is made as follows:
Gewebelagen with a size of 303,5 mmx303,5 mm from the fabric course (1 m broad) are cut. Then a drying process of the individual gewebelagen takes place with 110 DEG C for 2 hours. Subsequently, 58 of such gewebelagen is inserted into a fabric chamber. Over each other piles of the individual gewebelagen carbon fibers takes place under constant change from chaining and firing direction. Fiber orientation in each situation corresponds thus to 0 DEG and 90 DEG.

Resin infiltration

The polymer resin which can be infiltrated is brought in in a quantity of 1200 g into a resin chamber. The resin chamber as well as the fabric chamber are heated up on infiltration temperature by 70 DEG C and degassed at the same time by creation by negative pressure -0.3 bar. Subsequently, the infiltration of the resin is made by a connection channel into the gathering mold from carbon textile fabrics. The infiltration takes place in vertical direction under increase of the differential pressure between resin and fabric chamber in several steps from 0,3 to 2 bar. The resin becomes even over the lip of the gewebelagen, i.e. the face of the gathering mold, infiltrates. After the infiltration an outgassing of volatile components of the infiltrated polymer resin, a flushing with further, fresh polymer resin from the resin chamber takes place for removing from contaminated resin (fiber particle, degassing products, etc..) over the resin supply side facing the side of the fabric chamber, until the molded article is interspersed with pure resin completely. After infiltrating the polymer resin is hardened with 150 DEG C one hour and cooled down afterwards on ambient temperature. Subsequently, the in such a way manufactured green body, which possesses external dimensions of 305 mmx305 mmx15,6 mm, is taken out of the fabric chamber.

Thermal treatment

The in such a way manufactured green body is then subjected to a thermal treatment under air atmosphere with ambient pressure. The thermal treatment cycle is in Fig. 1, which shows the temperature as a function of the time in a diagram, represented. From this takes place heating ambient temperature first on 180 DEG C with a heating rate from 30 DEG C/h (thus for one duration from approx.. 5 hours). With reaching the temperature of 180 DEG this temperature will maintain for one hour; for construction units with particularly large wall thickness (more largely 10 mm) are to be kept retaining lasting up to 8 hours. Afterwards takes place a cooling under a defined cooling rate, which amounts to about 30 DEG C/h, until ambient temperature is reached. The total time of the thermal treatment results with approx.. 11 hours.

Mechanical intermediate's treatment

Here of the operational sequence a mechanical intermediate's treatment is accomplished, in order to adjust possible dimension inaccuracies of the green body and to work on it on approximately final dimension including a measure addition. Here the green body on dimensions is besaeumt by 288 mmx288 mmx15,6 mm by means of diamond saw. After this mechanical intermediate's treatment a drying process of the green body takes place with 110 DEG C for 2 hours.

Pyrolysis of the green body

Two green bodies 1, as they are managing described, become, as in Fig. 2 represented is between-added, between genuteten graphite plates 2, 3 and 4, whereby the graphite plates 2 and 4 are genutet only on that the green body 1 turned page, while the graphite plate 3 on upper and lower surface exhibits a genutete surface. The slots 5 are perpendicularly to each other running directions in such a manner implemented in two that collections 6 are formed in each case, which form the contact surfaces for the green body 1. The slots 5 serve to exhaust during pyrolysis arising gases. For this also additionally drillings 7 can be planned. The mass of the upper graphite plate 2 amounted to 10 kg, the mass of the middle graphite plate 3 likewise 10 kg. Thus a pressure load of approximately 1200 N/m<2 > for the upper green body 1 and of approximately 2600 N/m<2 results > for the lower green body 1. The arrangement is brought into a furnace chamber, from which after their latches air is sucked off. Subsequently, the furnace chamber with nitrogen under a rate is rinsed by 30 l/min..

The pyrolysis cycle is started while maintaining rinsing with nitrogen under a rate by 30 l/min.. Here a temperature distribution is stopped in the furnace, like it in Fig. 3 is represented. First fast heating takes place on 180 DEG C (thermal treatment temperature) with a heating rate from 100 DEG C/h. after reaching this temperature of 180 DEG C takes place further heating on a temperature of 570 DEG C under a heating rate of 10 DEG C/h. (individual lasting of the heating sections are the Fig. 3 to infer directly, whereby the lower (in parentheses set) number range shows the possible range of variation, during which upper value represents the preferential heating rate). The second heating stage is so for a long time accomplished, until a transformation took place from at least 70% of the polymer resin in carbon (in the example shown this length of time amounts to approx.. 39 hours).

In the third heating phase fast heating of 570 DEG C takes place to 900 DEG C, whereby the maximum pyrolysis temperature represents 900 DEG C. The heating rate is with approximately 100 DEG C/h. Regarding the lengths of time becomes again on Fig. 3 referred. Afterwards a fast cooling of 900 DEG C takes place on ambient temperature with a cooling rate of 100 DEG C/h, if necessary under forced cooling.

The green body is taken now from the furnace and it follows an examination regarding porosity, density and larger defects (e.g. pipes or Delamination). Under observance that managing indicated parameter are not defects to be determined. If such Delaminierung should arise nevertheless due to any irregularities, this construction unit is selected.

The pyrolysierten green bodies, the furnace taken, possess in each case external dimensions of 288 mmx288 mmx14,3 mm.

Silicon infiltration

In the described example silicon is infiltrated liquid into the pyrolysierten green body. However also the possibility exists of infiltrating silicon in steam form into the tear structure of the green body.

The infiltration of the liquid silicon takes place in a graphite tub with a diameter of 420 mm. The graphite tub is coated first with a boron nitride suspension, which is laid on with a brush. Afterwards the surface of the green body (288 mmx288 mm) in the coated graphite tub is centrically marked. On this marked surface 480 g silicon granulates in an evenly thick layer are then applied. Subsequently, presenting the

pyrolysierten green body takes place on the surface covered with granulates, whereupon further 240 g silicon granulates are applied evenly on the green body. Altogether into the graphite tub 720 g silicon granulates are brought evenly in such a way, which corresponds to 45 percentage by weight of the pyrolysierten green body. The granulates possesses a grain size up to 15 mm and a pollution of smaller 9 ppm. The graphite tub is then covered with a graphite cover, which is likewise coated with boron nitride suspension. After closing the furnace an exhaust of air takes place within the graphite tub and a flushing with nitrogen. Subsequently, a pressure is stopped and maintained in the furnace chamber by 10<->2 > mbar.

The furnace is heated now with a temperature distribution, like this in Fig. 4 is represented. First a heating takes place on 900 DEG C in a first heating stage under a heating rate from approximately 100 DEG C/h. This first heating period is accomplished over approximately 9 hours. Afterwards the heating rate reduction to 60 DEG C/h, until a temperature of 1650 DEG C is then reached, which lies above the fusing temperature of silicon. This temperature of 1650 DEG C is then regarded as 4 hours, so that it is ensured that the liquid silicon is infiltrated by the top side and the lower surface by capillary effect into the green body. From this a cooling with a cooling rate takes place from approximately 100 DEG C/h up to ambient temperature. After reaching a temperature of 50 DEG C with nitrogen rinsed under attitude of atmospheric pressure. The construction unit is taken and shows an external dimension of 286 mmx286 mmx14 mm. The construction unit is subjected then to a quality control regarding Delamination, remainder porosity and density by means of ultrasonic - and/or X-ray.

The shaped part manufactured in accordance with the managing procedure shows the following values:
Portion of free SI: 1,2%
Density: 1.92 g/cm<3 >
Remainder porosity: 5% related to the total volume
3-point bending strength = 80 MPa (l/d = 5, l = support distance and D = thickness of the molded article)
Fiber volume content: 64%
Ceramic(s) mass content (= SiC Massengehalt): 39%.

According to that managing indicated procedure can, under appropriate Dimensionsierung of the green body, construction units so be laid out that they are manufactured on final dimension, for example for brake disks or brake linings.

A finishing of the surface can take place to small extent by means of diamond saws, drills or Schleifern.

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Moulded body reinforced with carbon of fibres

Claims OF **DE19749462**

1. Procedure for the production one with carbon fibers of strengthened, keramisierten molded article, with which into carbon fibers a containing, porous gathering mold of the molded article polymer resin, in particular a polymer resin on phenol basis, is infiltrated and hardened, is subjected the in such a way received green body of a pyrolysis for the transformation of the polymer resin in carbon and in these thereafter silicon, in liquid phase, at a temperature of at least 1400 DEG C infiltrated, with carbon to siliziumkarbid is preferably reacted, by the fact marked that before pyrolysis the gathering mold infiltrated with polymer resin is heated up on a thermal treatment temperature, which is appropriate for 20 DEG C to 70 DEG C over the temperature, at which the polymer resin hardens that the thermal treatment temperature for one duration of at least 1 hour is maintained and afterwards the green body on ambient temperature with a cooling rate of at least 30 DEG C/h is cooled down that during the pyrolysis of the green bodies, of a mechanical pressure load rising with increasing thickness of the green body, insb. Surface pressure is subjected, and that after conclusion of the pyrolysis of the green bodies with cooling rates within the range of 30 DEG C/h to 300 DEG C/h on ambient temperature one cools down.

2. Procedure according to requirement 1, by the fact characterized that with a gathering mold with a structure of fabric from carbon fibers the polymer resin is injected over a section of fabric edge and over the entire thickness of the gathering mold into the gathering mold.

3. Procedure according to requirement 1, by the fact characterized that the thermal treatment is accomplished in air atmosphere with ambient pressure.

4. Procedure according to requirement 1, by the fact characterized that the heating is accomplished on the thermal treatment temperature in stages with different heating rates.

5. Procedure according to requirement 4, by the fact characterized that the heating is accomplished by ambient temperature up to thermal treatment temperature with heating rates within the range of 30 DEG C/h to 300 DEG C/h.

6. Procedure according to requirement 1, by the fact characterized that the surface pressure is accomplished by loading of the green body with punched and/or genuteten graphite or steel plates.

7. Procedure according to requirement 6, by the fact characterized that the surface pressure with genuteten plates is accomplished, whose did not genutete contact area between 30% and 60% of the total disk surface lies in each case.

8. Procedure after one of the requirements 1, 6 or 7, marked by it that the mechanical pressure load and/or surface pressure is accomplished at least with a pressure, from P = the 100 + tx65 [N/m<2 >] is calculated, whereby t = wall thickness of the gathering mold is in [mm].

9. Procedure according to requirement 1, by the fact characterized that with a gathering mold with a structure of laminate with two-dimensional fabric layers from carbon fibers the mechanical pressure load is distributed evenly perpendicularly to the fabric levels.

10. Procedure according to requirement 1, by the fact characterized that the pyrolysis of several green bodies is accomplished in the pile, whereby in the changing structure genutete pressure plates and green body the pile are arranged in an educated manner.

11 Procedure according to requirement 1, by the fact characterized that pyrolysis is accomplished in air atmosphere with a pressure </= 1 mbar or under inert gas.

12. Procedure according to requirement 11, by the fact characterized that pyrolysis under nitrogen is accomplished, whose purity amounts to at least 99.96%.

13. Procedure according to requirement 1, by the fact characterized that pyrolysis with heating and cooling

rates is accomplished within the range of 30 DEG C/h to 300 DEG C/h, preferentially with heating and cooling rates by 100 DEG C/h.

14. Procedure according to requirement 1, by the fact characterized that pyrolysis is accomplished in three heating stages, whereby the first heating stage up to the thermal treatment temperature with a heating rate within the range of 50 DEG C/h to 300 DEG C/h, which second heating stage with a heating rate within the range of 5 DEG C/h to 300 DEG C/h, until at least 70% of the transformation of the polymer resin took place in carbon, and which third heating stage with a heating rate within the range of 50 DEG C/h to 300 DEG C/h up to the pyrolysis final temperature are accomplished.

15. Procedure according to requirement 14, by the fact characterized that the first heating stage with a heating rate is accomplished by approximately 100 DEG C/h.

16. Procedure according to requirement 14, by the fact characterized that the second heating stage with a heating rate is accomplished by approximately 10 DEG C/h.

17. Procedure according to requirement 14, by the fact characterized that the third heating stage with a heating rate is accomplished by approximately 100 DEG C/h.

18. Procedure according to requirement 1, by the fact characterized that during the silicon infiltration an essentially constant temperature will maintain, whereby the length of time of the maintenance with the height of the temperature decreases.

19. Procedure according to requirement 18, by the fact characterized that during the silicon infiltration a temperature of < 1800 DEG C for a length of time of at least 3 hours will maintain.

20 Procedure according to requirement 18, by the fact characterized that during the silicon infiltration a temperature of > 1800 DEG C to approximately 2100 DEG C for a length of time of less than 3 hours will maintain.

21. Procedure according to requirement 1, by the fact characterized that with a gathering mold with structure of laminate from carbon fibers the silicon is supplied transverse to the structure of laminate.

22. Procedure according to requirement 1, by the fact characterized that silicon, which contains less than 9 ppm impurities is infiltrated.

23. Procedure according to requirement 1, by the fact characterized that the infiltration of silicon is accomplished in stackable graphite tubs.

24. Procedure according to requirement 23, by the fact characterized that before the infiltration of silicon between the green body and the graphite tub a parting agent is brought in.

25. Procedure according to requirement 24, by the fact characterized that as parting agent a suspension, which contains an aqueous solution of boron nitride powder and an adhesion mediator is brought in.

26. Procedure according to requirement 1, by the fact characterized that the green body is dried during a length of time by approximately 2 hours at a temperature of approximately 110 DEG C.

27. Use in the procedure after one of the requirements 1 to 26 manufactured molded articles for brake disks.

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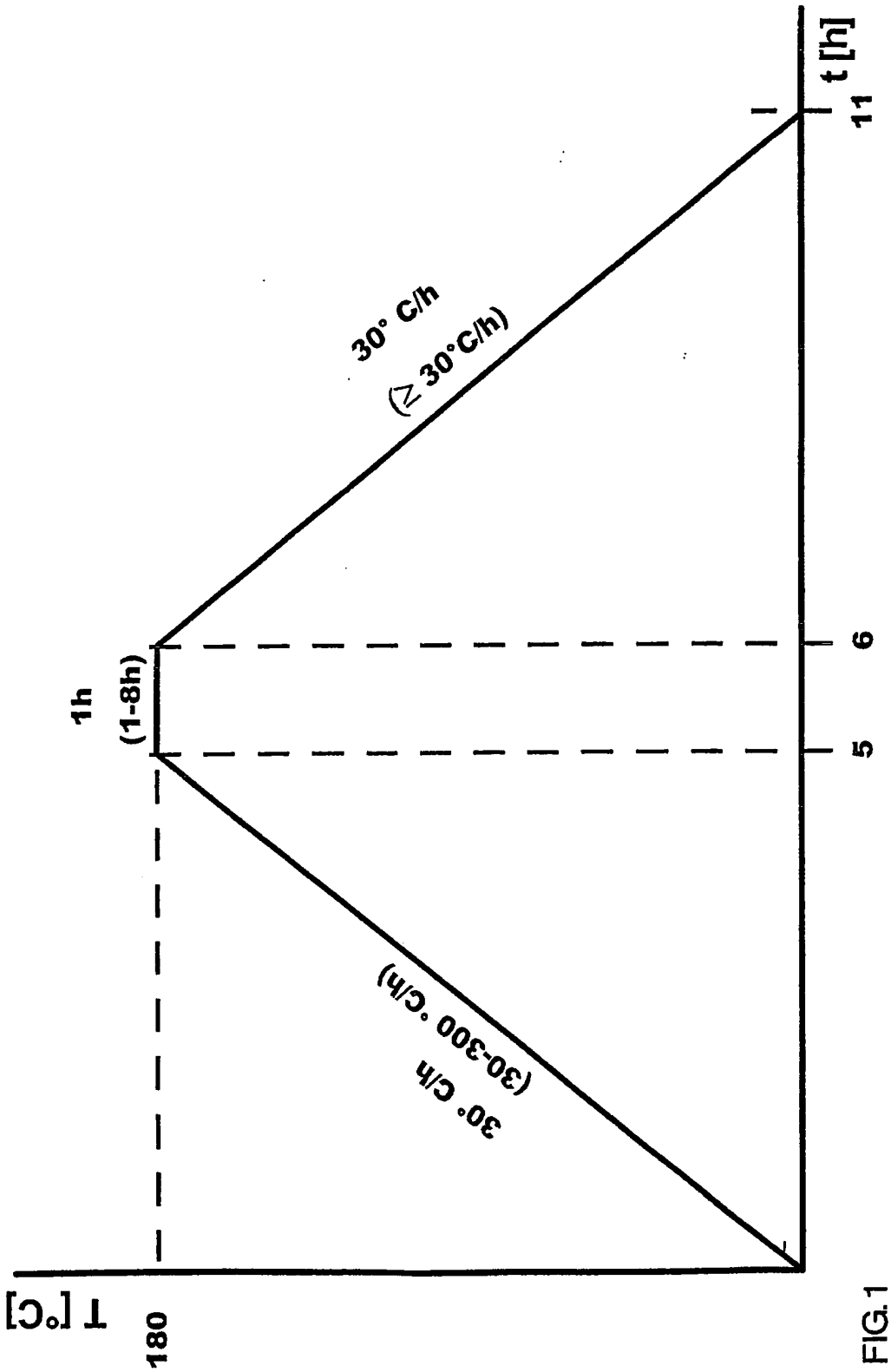

FIG. 1

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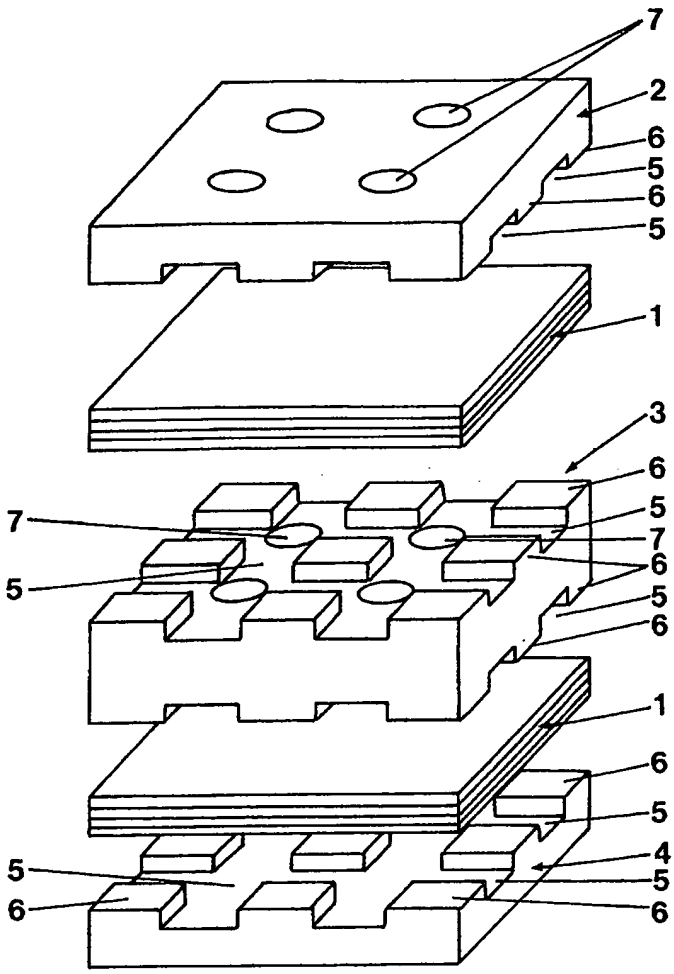

FIG. 2

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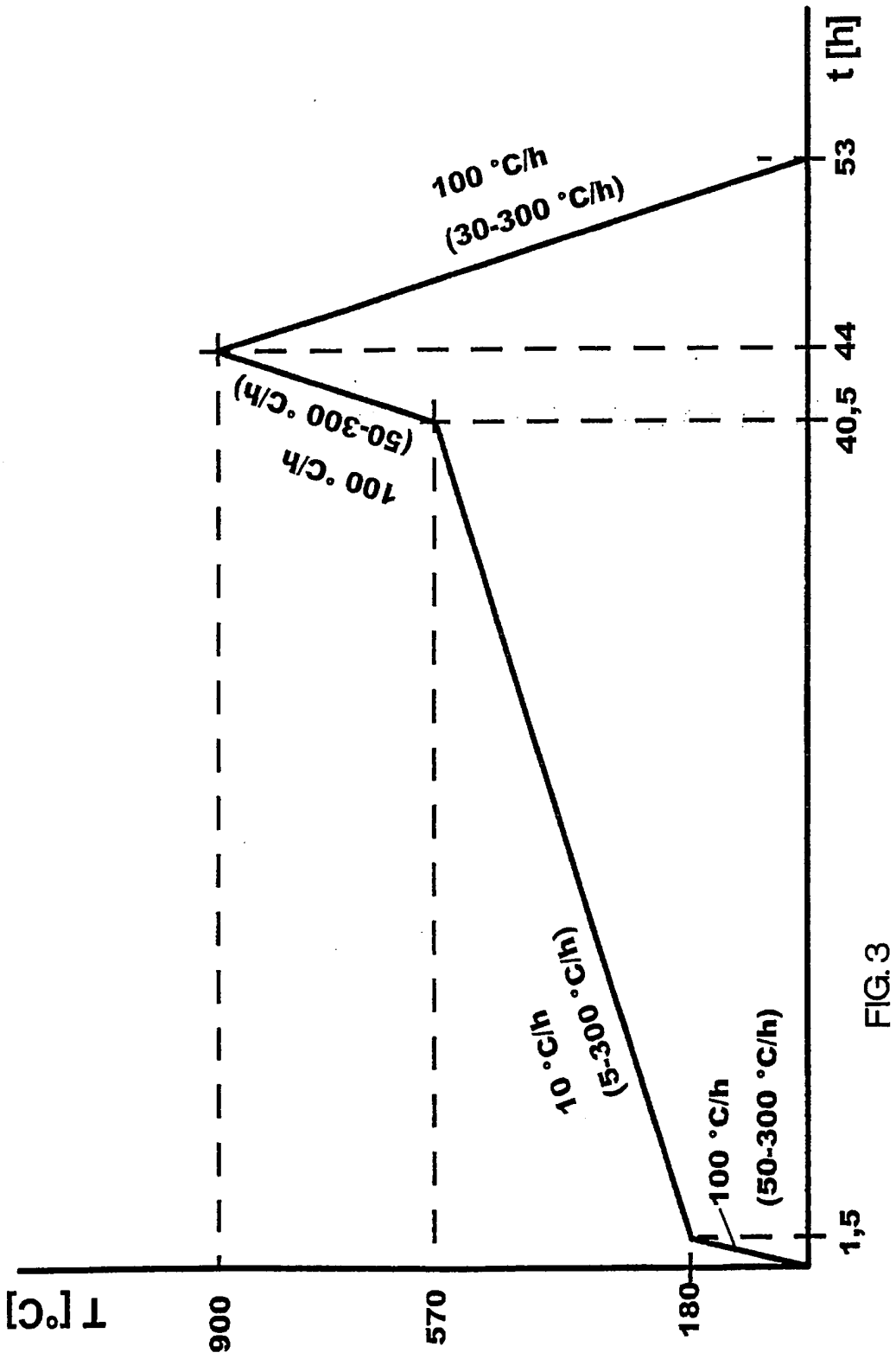

FIG. 3

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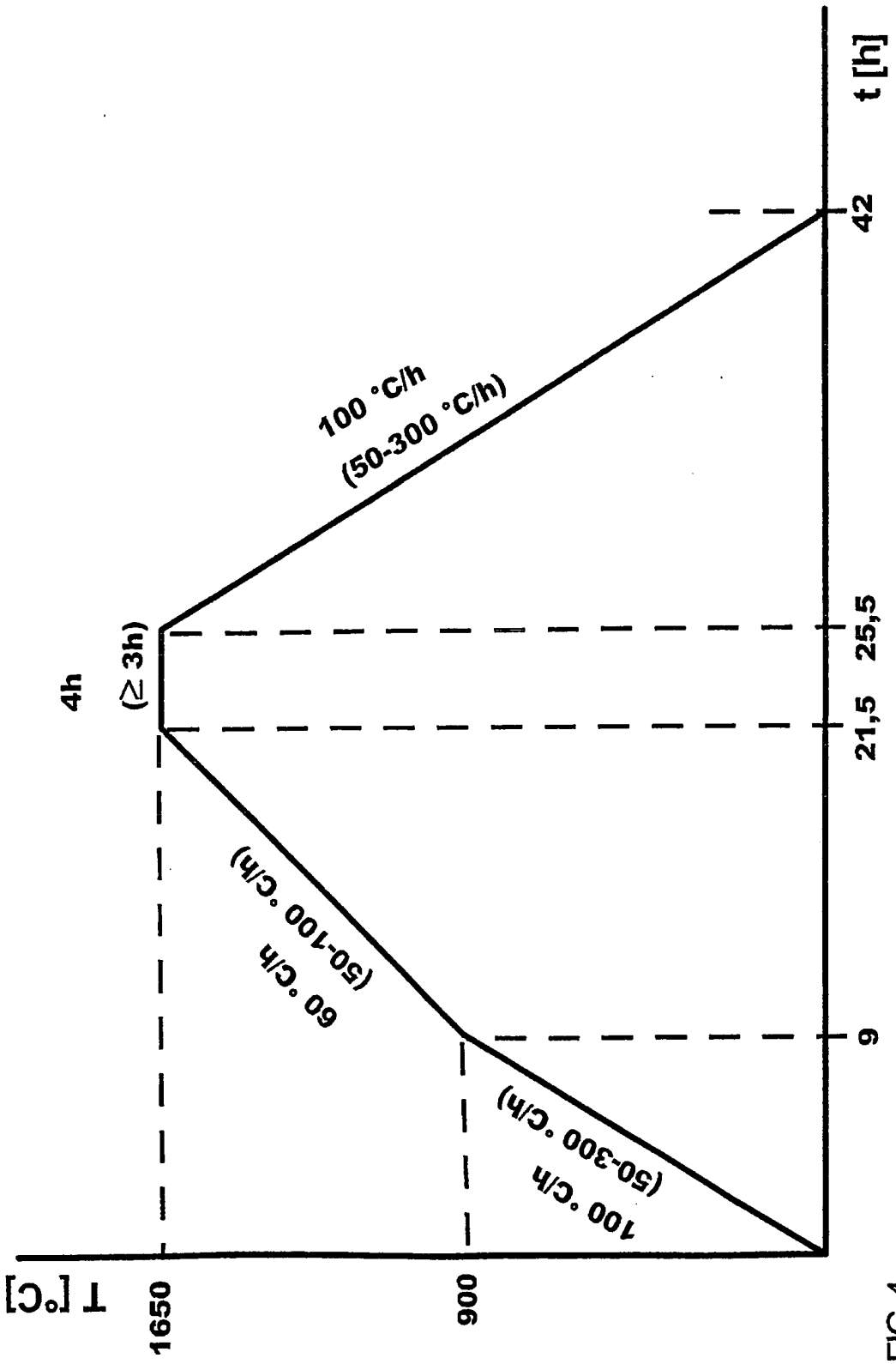

FIG. 4